TITLE: UCAV Concepts for CAS

# UCAV CONCEPTS FOR CAS

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## SUMMARY
A system concept is described that would give individual combat users access to and (limited) control of a network of unmanned air vehicles. Applications would be both lethal and nonlethal. In the nonlethal form, unmanned combat air vehicles could respond to fire support requests as if they were the virtual equivalent of organic, long-range artillery. In the nonlethal form, unmanned reconnaissance air vehicles could point their sensors at locations and/or areas of interest and respond with target imagery or coordinates of selected target types. Capabilities currently exist to evaluate these concepts in simulated or actual field trials and/or to develop an initial operating capability (IOC).

## NOTATION
CAP - combat air patrol
CAS - close air support
CITS - CAS Integrated Targeting System
CONOPS - concepts of operation
COTS - commercial off-the-shelf
FO – forward observer
GOTS - government off-the-shelf
GPS – global positioning system
IOC - initial operating capability
IPT - integrated product team
ISR - intelligence, surveillance, and reconnaissance
LM - Lockheed Martin
LMTAS - Lockheed Martin Tactical Aircraft Systems
SOW - standoff weapon
TACP - tactical air control party
TCS - Tactical Control System
UAV - unmanned air vehicle
UCAV - unmanned or uninhabited combat air vehicle
URAV - unmanned reconnaissance air vehicle
USAF - United States Air Force
USMC - United States Marine Corps

## 1. INTRODUCTION
For many years an uneasy relationship has existed between advocates of manned and unmanned air vehicles (UAVs). Manned aircraft advocates recognize UAVs as an inevitable element of the future tactical air environment, but also see them as competitors for missions and resources. Unmanned system advocates, on the other hand, tout the potential synergy between manned and unmanned air operations but praise their concepts as *alternatives* to the high cost and risk of manned systems.

At Lockheed Martin Tactical Aircraft Systems (LMTAS), the unmanned combat air vehicle (UCAV) integrated product team (IPT) has advocated a mix of manned and unmanned systems, but it has not been easy to articulate exactly how this will work[1]. However, recent technical and operational developments, including employment of Lockheed Martin (LM) Close Air Support (CAS) Integrated Targeting Systems (CITS, also known as LM "Sure Strike" Systems), have suggested new ways of employing UAVs and UCAVs to support ground operations.

The CITs Sure Strike System, developed and patented by LMTAS, is operational with U.S. Air Force (USAF) units deployed to support operations in Bosnia/Yugoslavia. This system enables the operator to determine GPS coordinates by aiming it at a desired target. The system then transmits GPS data and other pertinent information directly to CAS aircraft. Currently, this streamlined CAS targeting and digital communication system is interoperable with F-16 units based at Aviano, Italy.

Extending Sure Strike capability to be interoperable with other manned and future UCAVs could be readily accomplished. Further, combining this type of system with GPS-aided weaponry would allow many different types of combat aircraft (including UCAVs) to effectively attack targets from higher altitudes—and in all-weather conditions—under the control of a local forward observer (FO). In essence, the aircraft would function as the virtual equivalent of long-range organic artillery. Extending this basic concept to that of putting sensors "on target" could allow FO direct control of UCAV and UAV sensors and line-of-sight receipt of images. As the system concept unfolds, it becomes clear that the end result is a potential *network* of UAVs and UCAVs capable of providing reconnaissance and/or fire support for any validated user.

### 1.1 Unmanned Air Vehicles
The term "UAV" describes a variety of unmanned air vehicle types ranging from what are essentially militarized radio-controlled tactical models to large, sophisticated sensor platforms that fly theater-level intelligence, surveillance, and reconnaissance (ISR) missions. Many other UAV types are also being developed and/or considered that cover an even wider range of sizes and missions. At one extreme are micro-UAVs, carried and launched by individual soldiers, for use on "close-in" missions that range from reconnaissance and

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intelligence-gathering to surgical strike. At the other end are UCAV, whose primary purpose is air-to-ground strike against targets which, for any number of reasons, are assigned to unmanned, instead of manned, aircraft. Finally, there is another class of vehicles not normally considered UAVs that perform unmanned air-to-ground strike missions—cruise missiles and air-launched standoff weapons (SOWs). Technically, these systems have all of the characteristics of traditional UAVs except in their early phases of flight (boost-launched and/or carried as payload) and their terminal phases—they fly one way to the target and are not recoverable. Otherwise, they can perform many of the functions of other UAVs, which include flying ISR, electronic warfare (EW), and strike missions. For the purpose of this paper, therefore, UAVs will be considered to fall into four basic UAV types (Figure 1): URAV, TUAV, UCAV, and SOW.

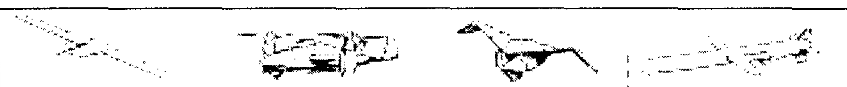
*1.1.1 Unmanned Reconnaissance Air Vehicles (URAVs)*
The distinguishing characteristic of this UAV type is its intended use—support of high-level decision makers (theater commanders, their staffs, and planners) with timely ISR. The need for timely information at these levels is nearly insatiable, and even though lower level users can request support, experience has shown that they do not fare well in comparison. Interestingly, the problem is often not the availability of information, but rather its processing and dissemination. ISR information processing and distribution is a traditional intelligence function, one that has a hard time keeping up with demands from higher command levels. Lower level commanders and their staffs, therefore, have started to demand better access via another type of UAV.

*1.1.2 Tactical Unmanned Air Vehicles (TUAVs)*
TUAVs perform a URAV-like function for lower levels of the command structure, down to and including individual fighting units. For definition purposes we include micro-UAVs, which drive the customer base down to the individual soldier, sailor, airman, or marine. Experience with TUAVs in combat and exercises has shown them to be extremely valuable for the commander who has them and detrimental for those who do not. As a consequence, we can expect them to have high user demand (and be high-value targets for enemy forces). Like URAVs, the demand for timely analysis and information dissemination can be a limiting factor for product users.

*1.1.3 Unmanned Combat Air Vehicles (UCAVs)*
UCAVs are a relatively new type of UAV whose primary function is to deliver ordnance. Near-term capability ranges from preplanned strikes against fixed ground targets to suppression of enemy air defenses (SEAD). Longer term capabilities cover a full range of missions including carriage of new weapon types that are uniquely suited to the UCAV concept[2]. Most projected applications are driven by relatively traditional manned and unmanned concepts of operation (CONOPS). Some authors, however, have proposed unique new applications such as support of ground maneuver units under the control of forward ground elements[3].

*1.1.4 Standoff Weapons (SOWs)*
Given their publicity in recent air combat operations, SOWs need little introduction. This paper, however, will more broadly define a SOW as any precision-guided weapon that allows friendly forces to stand off from the enemy and to precisely put ordnance on target. Even though SOWs are included in this paper as unmanned vehicles, employment concepts are generally driven by their launch platforms. Therefore, SOWs will not be addressed separately, but rather as elements of other platforms.

**1.2 Close Air Support (CAS)**
CAS can have different meanings. For the purpose of this paper, CAS is defined as any mission involving aerial delivery of weapons in direct support of, or in close proximity to, friendly ground forces. Basically, it is a mission that requires extremely close coordination between air and ground elements to ensure that weapons are accurately placed on enemy positions. These types of missions involve strict rules of engagement and require unambiguous ground coordination and/or control *prior* to weapon release.



| | URAV | TUAV | UCAV | SOW |
|---|---|---|---|---|
| • Mission | Recce (Primary) | Recce (Primary) | Strike (Primary) | Strike (Primary) |
| • Speed | L-M | L | M-H | L-H |
| • Maneuverability | L | L-M | M-H | M-H |
| • Altitude | M-H | L | L-M<br>M-H | L-M<br>M-H |
| • Observables | M-L | M-L | L | M-L |
| • Payload | 500 - 2000 lb | < 500 lb | 500 - 4000 lb | < 4000 lb |
| • Sensors | RF / EO / IR | EO / IR | RF / EO / IR | Targeting |
| • Bandwidth | H | M-H | L-M or H | L |
| • Endurance | Days - Weeks | Hours | Hours - Days | Hours |

L – Low M – Medium H – High

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Figure 1. Unmanned Air Vehicle Types

*1.2.1 Air-Ground Coordination*

One reason for the complexity of the CAS mission is that it involves two individuals, one in the air and one on the ground. Both have to be convinced that other understands the tactical situation, the deployment of friendlies, the threats, and the precise location of the intended target. Each may have a unique level of understanding and will have to rely on communications to convey that knowledge to the other. Adding to the complexity of the situation is the traditional reliance on voice communications and its inherent potential for misunderstanding and mistakes.

Although each party will share a common tactical objective, each will have individual concerns and motivations. The person in the air will be concerned about getting shot down and will want to minimize aircraft exposure. The person on the ground will be concerned about the potential for weapons falling on him/her or his/her troops and will want to minimize the potential for error. The two parties also operate in very different environments and see events unfolding at different speeds. As a consequence, the time required for them to achieve a sufficient level of understanding to allow weapon release can be significant, 20 minutes or more from aircraft arrival to weapon release if in a restrictive environment. Fortunately, technology has improved this situation, especially GPS, common reference digital maps, and air-ground datalinks.

*1.2.2 CAS Integrated Targeting System (CITS)*

State-of-the-art technology has revolutionized communication and coordination for CAS operations. Although a number of systems are under development, only one has been deployed—the USAF/Lockheed Martin patented Sure Strike CITS. The USAF CONOPS for CAS (Figure 2) assigns coordination responsibility to a ground-based tactical air control party (TACP) manned by USAF personnel. Sure Strike provides the TACP with a man-portable system that interfaces with F-16 Block 40 aircraft via an improved data modem (IDM), low bandwidth datalink. The Sure Strike system (Figure 3) integrates many commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) systems, which allow the TACP to quickly and precisely geo-locate enemy ground targets and digitally transmit them as GPS target coordinates *directly* to the F-16 by means of a standard "9-Line" digital message.

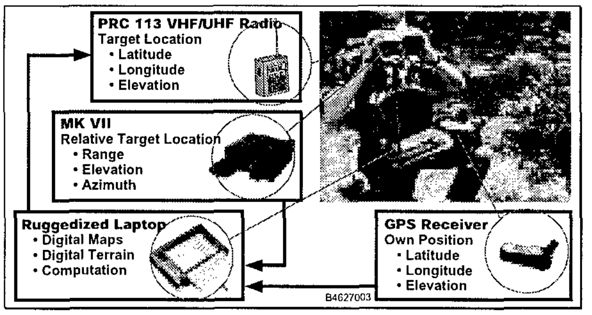


Figure 3. LM Sure Strike Ground Station

*1.2.3 F-16 Interface*

Upon receipt of the Sure Strike CITS message by the F-16, the pilot receives a heads-up display (HUD) indication while the target GPS coordinates are automatically passed to the F-16's Fire Control Computer (Figure 4). Sensors and weapons are aimed at the target, allowing the pilot to quickly acquire and confirm it with the TACP. The final step is the attack, which is executed by the pilot with the concurrence of the TACP. Although

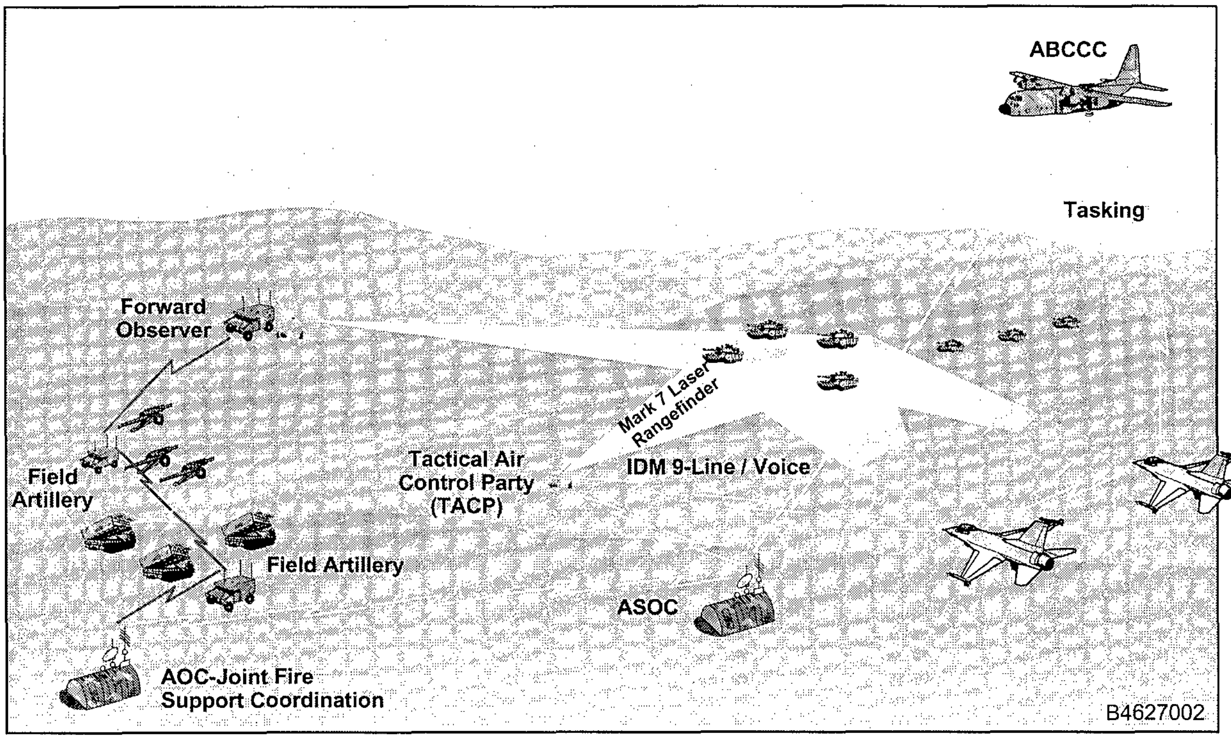


Figure 2. F-16 Sure Strike CONOPS

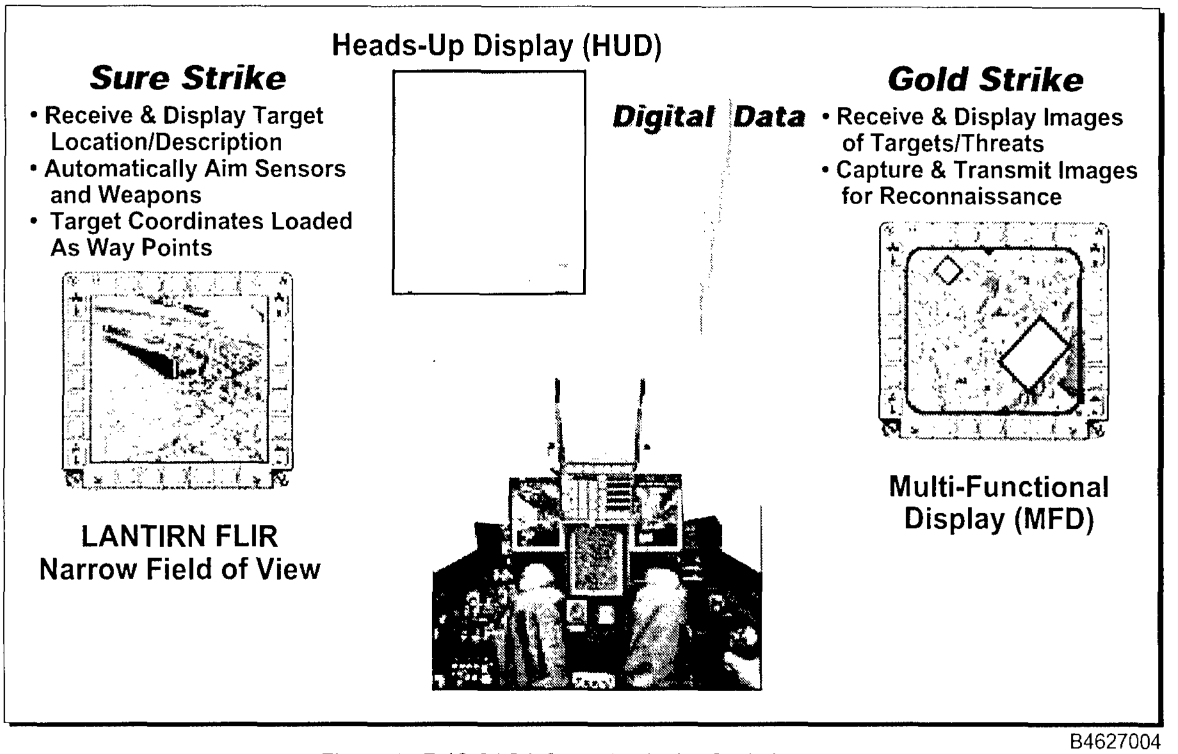


Figure 4. F-16 CAS Information in the Cockpit

little more than a straightforward adaptation of existing CONOPS and technology, Sure Strike has reduced CAS coordination and communication times by an order of magnitude.

*1.2.4 "Gold Strike" Enhancement*

Currently developed but not deployed is the enhanced LM "Gold Strike" CITS, which adds digital imagery capability to Sure Strike transmissions. This allows the TACP to uplink a digital situation awareness map to the pilot and/or to receive air vehicle sensor images on the ground (Figure 5). Although not originally intended for this purpose, Gold Strike allows any appropriately equipped air vehicle to be tasked for and to disseminate sensor images to other combat users in the air and on the ground. This function is performed using existing tactical radios since the IDM is a modem, not a separate datalink. This inherent capability sparked the idea of adapting the Gold Strike concept to local tasking and reception of tactical and reconnaissance UAV sensor products.

## 2. OPERATIONAL CONCEPTS

Although intended to bring revolutionary new capabilities to the battlefield, in essence, UAVs have entered the force as relatively straightforward unmanned equivalents of manned aircraft. However, experiments are underway to develop UAV-unique operation and control concepts. These experiments should transition to not only new operation and control concepts, but also to new concepts for ISR product analysis and dissemination. If they do not, future UAV effectiveness will be constrained, and overall force effectiveness will be impacted accordingly.

### 2.1 Manned Air Operations

For sound operational and tactical reasons, manned aircraft tactics and operation and control concepts have relied on pilots to exercise individual initiative and to be the final decision authority for himself and his aircraft and/or flight of aircraft. The tactical air battle is fast-paced, and the pilot's position in the middle

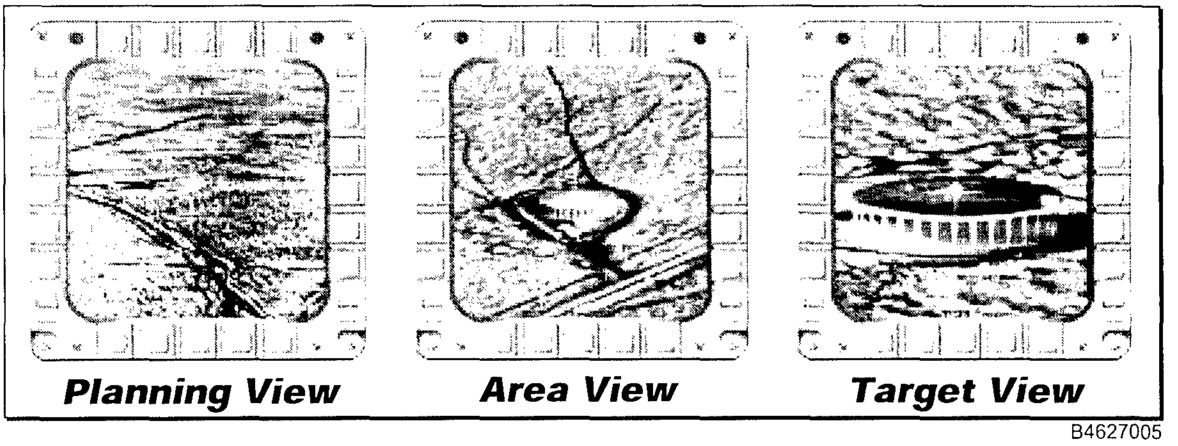


Figure 5. LM Gold Strike Imagery

of, or above, the fray usually puts him in the best position to make tactical decisions. As the tactical air environment has become more complicated (and crowded) it has become necessary to better coordinate among aircraft. Hence, the concept of air controllers developed. Regardless of the title, the job of the controllers is to coordinate, and individual pilots and/or flight leaders retain the ultimate control authority.

### 2.2 Unmanned Air Operations

From lessons learned over decades of manned aircraft operation, it is logical to assume that UAV operators should have an air vehicle command function comparable to their manned aircraft counterparts. In fact, early UAV operators were remote pilots and had "stick and rudder" control over their air vehicles. Today they exercise a higher level of control, more comparable to a mission manager, but UAV operators still retain traditional pilot-in-command authority. This, however, may not always be the best control concept. The U.S. Army, for example, is developing a capability for a Hunter UAV to be controlled from the cockpit of an Apache helicopter[4]. In this application, the Hunter functions as an extension of onboard Apache sensors. Clearly a ground-based operator, in this situation, would be ill-suited to exercise control over the UAV. Instead, he will hand off control to the Apache for a period of time and take it back when the Apache no longer needs it. During this period of time, the ground-based operator presumably would monitor the UAV and reassume control if necessary.

The U.S. Navy has conducted similar experiments in which Predator UAV control has been passed among multiple users to include submarines. UAVs have also been "forward passed" to Marine ground units. If development of these UAV operation and control concepts continues, the traditional pilot-in-command concept will be quite different from manned aircraft.

### 2.3 Other Manned Influences

Manned aircraft operation and control concepts also influence other UAV operations. For example, manned ISR aircraft typically separate the functions of aircraft control, sensor management, and data analysis and dissemination. To allow the pilot to concentrate on flying the aircraft, a second operator, sometimes on the ground, controls the sensors. Information processing and dissemination is separated because it is an air intelligence function and involves separate skills, clearances, and organizational responsibilities.

Even though UAV operator workloads and environments are different, the same approach is used. One UAV controller usually is responsible for flight path management, and another has responsibility for sensor management and control. Sometimes a separate station is used for launch and recovery and another for mission planning and replanning. Yet another station (often a separate van) processes and disseminates the data. This approach can result in UAV operator-to-air-vehicle staffing ratios that far exceed those of manned aircraft.

## 3. PROJECTED CONSTRAINTS

Current concepts of UAV operation, control, and information distribution are based on operational models originally developed to support limited numbers of users with predefined requirements and needs. All indications are that the demand for UAV support products will continue to increase. What is not clear, however, is whether constraints imposed by traditional UAV concepts of operation and control will be able to keep up with the potentially explosive growth in user demand.

### 3.1 ISR

URAVs primarily support theater commander and planning staff needs. Missions are scheduled well in advance to meet staff and intelligence needs, and product dissemination is planned accordingly. Ad hoc demands from lower level users, therefore, are difficult to accommodate. The challenge is not only planning and collection for multiple users, it is also information analysis and dissemination. There often simply are not enough available intelligence analysts to meet the time-critical needs of larger numbers of tactical users.

### 3.2 Tactical Reconnaissance

TUAVs probably will have the same constraints as URAVs, except they will occur at lower levels—ad hoc demands from lower unit level users may prove difficult to accommodate. Once again, the problem may be available manpower. TUAV operators and information specialists will be focused on supporting their primary users, and other demands will be prioritized accordingly.

### 3.3 Weapon Delivery

UCAV CONOPS are still in the experimental stages of development, but current trends are to plan and execute their missions like manned aircraft. Targets and/or support missions will be planned in advance, and UCAV operators will function like strike package managers. Once again, ad hoc requirements from lower levels of the organization may be difficult to accommodate.

### 3.4 Multiple Users

The more capability UAVs bring to the battlefield, the more people will want to use them. Although technology can help resolve some constraints, e.g., application of state-of-the-art flight path and sensor automation technology to reduce UAV manpower, it will not provide a complete solution. Fundamental CONOPS changes will be required to resolve inherent constraints in traditional operation and control concepts to meet time-critical demands of larger numbers of increasingly demanding combat users.

## 4. ALTERNATE COTS-BASED "CONOPS"

There are many well-developed commercial operation and control concepts that could meet future multiuser demands for timely combat air support. They are applicable to UAV and UCAV operation and control concepts and ISR information processing and dissemination.

### 4.1 Internet

Internet-like, database concepts have well-recognized capabilities to meet multiuser demands for timely information. Included are near-real time, dynamic database approaches that can meet many ISR needs (e.g., time-annotated imagery retrieval by users with appropriate security access codes)[5]. In situations where database products will not meet combat information needs, other approaches can be considered.

### 4.2 Delivery Services

The consumer service industry is replete with operation and control concepts that efficiently respond to time-critical, multiuser demands. A tongue-in-cheek example is pizza delivery, which operates on the fundamental premise of a universally available command and control system (a phone and a credit card), an agreed-upon list of available products (a menu), and a quick response delivery system. A more sophisticated example is automated taxi dispatch. Customer service requests (pick up time and location) go directly into a time-sequenced database that is digitally transmitted to potential providers (subscribing taxi drivers) based on their last reported location. The first driver to respond (by screen touch) gets the fare and assumes responsibility for meeting the user requirement. Similar concepts have been envisioned for military applications such as sensor-to-shooter pairing.

## 5. ARTILLERY-BASED CONOPS

Field artillery has a well-developed concept of operation and control that could be adapted to meet multiuser, time-critical UAV and UCAV support requirements. Artillery must not only support a large number of users located all over the battlefield, but it also has to meet stringent response-time requirements. Since it performs a CAS-like function, the discussion will start by comparing the two. Nonlethal applications that are based on this same concept will be addressed in subsequent sections.

### 5.1 Tasking and Coordination

Both artillery and CAS collocate trained specialists (forward observers and forward air controllers) with ground units to direct and coordinate support. There are, however, differences. Forward observers are usually "organic" to ground maneuver units, while FACs function at the interface of the air and ground forces.

### 5.2 Targeting

Forward observers task gun crews for fire support using map coordinates. The gun crew responds with a round calculated to hit the target. Using plus/minus corrections, a forward observer directs subsequent rounds onto the target and finally gives authority to "fire for effect." A FAC, on the other hand, uses ground features to orient the pilot about locations of friendly forces, enemy forces, and potential threats. The reason for visual features vice map references is that air and ground forces use different maps and map references. A forward observer uses a map with features and symbols optimized for ground operations, and the map will be annotated with the location of friendly forces and will contain tactical updates not available to the pilot. Pilots use maps in latitude and longitude designed to support air operations that do not include many of the features of the ground-focused version. Thus, the two maps have different reference bases that must be correlated.

### 5.3 Responsibilities

In artillery support missions, responsibility is shared between the forward observer and the gun crews. The forward observer is responsible for providing accurate target coordinates and corrections. The gun crew is responsible for putting rounds on the designated location. If there is an error, a short round for example, responsibility is assigned accordingly. On CAS missions, responsibility is not shared, it is transferred—different organizations and, sometimes, different services are involved. In the U.S. armed forces, only the U.S. Marine Corps (USMC) has an organic fixed-wing CAS capability. The U.S. Army has organic rotary-wing CAS assets, but depends on the U.S. Air Force for fixed-wing CAS. With the exception of the USMC, organic vs. nonorganic support is a major issue, and the services involved typically do not assume mutual responsibility.

### 5.4 Command and Control

Even though a gun crew that responds to a forward observer may be unknown to him and organizationally detached, from his perspective, the crew is responding directly to his command. In reality, there are a number of intervening levels that exercise command and control, which include the assignment of the observer's request to a particular gun. Command and control is by exception. Intervention occurs only when a problem is perceived; otherwise, approval is automatic. On CAS missions, command and control can be similar. Forward air controllers have authority for all CAS missions in their assigned area of responsibility, and higher command levels intervene only under unusual circumstances.

## 6. UAV/UCAV APPLICATIONS

Nontraditional operation and control concepts have the potential to not only enable unique new UAV and UCAV applications, but also to revolutionize ISR information production and dissemination. That is not saying that new concepts will supplant traditional concepts, rather that they could supplement them when quick-reaction, direct support of multiple users is required. As examples, CAS and ISR support of small units will be addressed.

### 6.1 CAS

The potential exists for UCAV to function as the virtual equivalent of long-range, organic artillery (Figure 6). This application has a number of advantages, one of which is the ability to provide quick-response, precision-fire support anywhere on the battlefield.

| Artillery | UCAV |
|---|---|
| • Direct Fire Support Assigned to Ground Maneuver Unit | • UCAV Flight Assigned to Support Ground Maneuver Unit |
| • Fire Support Unit Positions to Cover Assigned Maneuver Unit | • UCAV Flight on CAP to Cover Assigned Maneuver Unit(s) (or on Strip Night at Forward Operating Base) |
| • Maneuver Unit Identifies/Locates Target (UTM Reference), Requests Fire Support | • Maneuver Unit Identifies/Locates Target (UTM Reference), Requests CAS |
| • Forward Observer (FO) Receives/Reviews Request | • FO/FAC Receives/Reviews Request |
| • FO Geolocates Target, Tasks Fire Support Unit (Digitally) | • FO/FAC Geolocates Target, Transmits 9 Line Message (Digitally) |
| • Target Assigned to Gun Crew (Digitally) | • Target Assigned to UCAV, Released for Mission (By UCAV Operator) |
| • Cut Charge, Load, Fire One<br>• Adjust Fire<br>• Fire for Effect | • UCAV Reports Inbound, Confirms IP and Weapon Target Coordinates<br>• FO/FAC Confirms/Adjusts Target, Weapon Release Authorized |

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Figure 6. UCAV Artillery Analog

#### *6.1.1 Tasking*

UCAV air vehicles would either sit-strip alert or loiter above the battlefield while awaiting requests for fire support. Forward observers would generate requests for support using standard preformatted artillery fire support messages. Like the "pizza delivery" analog, a universally available standard tactical radio would be used to place the order. Fire support requests would identify observer, friendly and target GPS locations, and attack direction plus other standard targeting information. Requests would be sent to an artillery fire control center and forwarded to a supporting UCAV unit when distances involved exceed available artillery capabilities. An automated taxi dispatch-like system could be used to task the UCAV network.

*6.1.2 Operator Control*
Upon receipt or acceptance of an air support assignment, a UCAV operator would designate an air vehicle (or strike package) to respond and immediately send it toward the target area. While enroute, the operator would use automated planning tools to generate a detailed mission profile that includes routing to avoid threats and/or friendly air operations. An updated plan would then be transmitted to the enroute UCAV along with an access code to allow the forward observer to assume limited, local control when within line-of-sight (LOS). The UCAV operator would transition to a monitoring role when the forward observer authenticates his identity and assumes local control responsibility.

*6.1.3 Limited Local Control*
Upon initial contact, the UCAV would transmit a digital message describing its mission, weapons load, designated target, etc. (Figure 7). Target location would either be in the form of GPS coordinates displayed on a digital tactical map and/or as a target image from an onboard UCAV sensor. The forward observer would either confirm the target/mission as received and authorize weapon release, call off the attack, or update or refine the target. In the last case, the UCAV would repeat the new information back to confirm targeting prior to weapon release. After the attack, the UCAV could be directed to provide bomb damage assessment information and/or re-attack under local control. As a result of the artillery-based operation and control concept, artillery-like response times are projected (Figure 8). Responsiveness would be a function of platform speed, altitude, and distance to target. A CAS UCAV with fighter-like speed capabilities and delivery profiles, therefore, could match artillery for weapons time on target.

*6.1.4 Hand Back*
Upon successfully completing its mission, the forward observer would notify the UCAV operator, who could either return it to base or assign it in another CAP location. Note that while the forward observer assumed limited control, the UCAV operator monitored the vehicle and could reassume control if required. This would allow the forward observer to concentrate on his mission (putting weapons target) and eliminate any requirement to deal with UCAV system-unique demands.

*6.1.5 Benefits*
In addition to artillery-like response times, a number of benefits accrue (Figure 9). Most of them are enabled by the fundamental concept of limited local control during the attack phase. The need for lengthy coordination between air and ground participants is effectively eliminated. The anxiety level and potential for errors drops accordingly.

**6.2 Reconnaissance**
A similar approach could allow individual ground units to task UAVs for ISR support and information dissemination. A local maneuver unit, for example, could generate a request for imagery or surveillance support of ground operations. If up-to-date imagery was not resident in a database, the request could be sent to an appropriately located UAV to point its sensors at a designated target and respond with imagery or an update of the local tactical environment. If no UAV was in position, with sufficient priority, one could be instructed by its operator to alter its flight path. In either case, the role of the UAV operator would not be to control the sensors or fly the UAV, but rather to service the user requests, assign them to the most appropriate asset for execution, and ensure timely responses against stated user requirements.

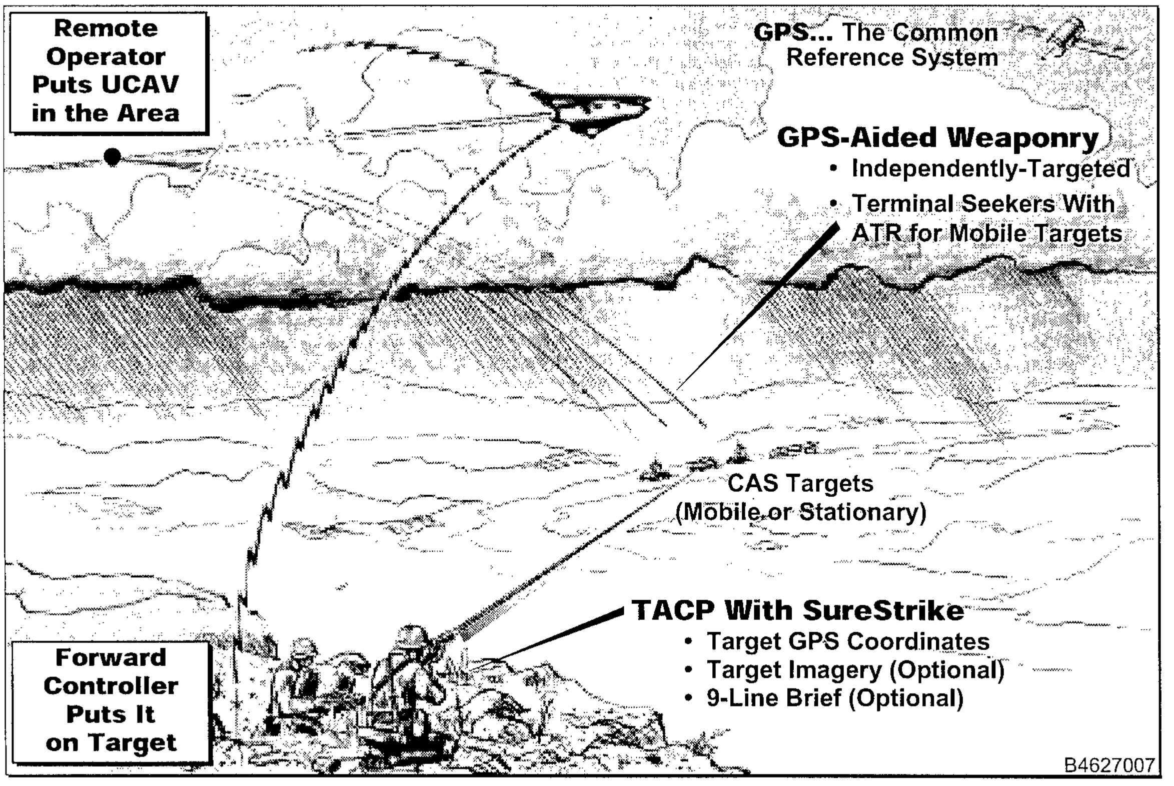


Figure 7. UCAV "Airborne Artillery"

**Assumptions**
- IP to Target – 5 n.mi
- UCAV TAS – 540 kt
- Weapon Release From 15 K'

| Event | Elapsed Time (Sec) From CAP @ 10 nm | 25 nm | 50 nm |
|---|---|---|---|
| • FO/FAC Receives Fire Support Request (Digital) | 00 | 00 | 00 |
| • 9 Line Message Xmit | 15 | 15 | 15 |
| • UCAV Assigned, Released From CAP | 25 | 25 | 25 |
| • Mission Planned/Authorized (UCAV Operator) | 50 | 50 | 50 |
| • UCAV Released to FO/FAC | 55 | 55 | 55 |
| • UCAV Reports Inbound | 55 | 55 | 55 |
| • IP and Target Coordinates Confirmed | 70 | 70 | 70 |
| • 10 Sec From IP, Cleared for Weapon Release | 80 | 180 | 350 |
| • Weapon Release (From 15k') | 100 | 200 | 370 |
| • Weapons on Targets | 130 | 230 | 400 |
| • Available for Reattack | 165 | 265 | 435 |
| • Next Weapon on Target | 195 | 205 | 495 |

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Figure 8. UCAV CAS Timelines

- Reduce Number of People Involved
  - Theoretical Minimum = 1 (During Attack)
- Minimize Number of Organizations Involved
  - Theoretical Minimum = 1 (At Any Given Time)
- Reduce Anxiety Level
  - FO/FAC In Charge of Attack
- Minimum Communication Time
  - Single Burst Transmissions(s) From Ground-to-Air
  - Single Burst Confirmation From Air-to-Ground
- Provide Single Ground Reference System
  - Standard Map
    and/or
  - High Resolution Image

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Figure 9. CAS UCAV Benefits

Unlike the CAS example, however, response times would not be driven as much by platform speed and distance to target. A standoff UAV within line of sight would be able to image the target at the speed of light, assuming its sensors have sufficient resolution at the distances involved and that bandwidth was adequate.

## 7. USER-CONTROLLED AIR VEHICLE SYSTEM CONCEPT

A logical extension of the UAV operation and control concepts and information processing and dissemination discussed previously is a universally accessible system for all unmanned air assets positioned over the battlefield to support multiuser needs. We will describe this as a User-Controlled Air Vehicle System, but will refrain from using an acronym to describe it. Instead, we will use the term StrikeNet, a LM implementation of this basic system concept. In our vision, StrikeNet would support multiple users at multiple locations and involve multiple services, weapons, and platforms including SOWs (Figure 10). It would be enabled by the concept of network-centric warfare, in which all battlefield participants are able to exchange digital information with and gain access to whatever information source is necessary to accomplish their mission. It would, however, not have to wait for full implementation of the network. The system would be based on a modular, open architecture and could use any existing tactical datalink and/or modem to transmit or receive digital data. Connectivity could be established wherever communication links exist; performance would simply vary with available bandwidth. Because the system concept is based on communicating by short-burst digital instructions or responses and (preferably) freeze frame sensor images, required bandwidth would be minimized.

### 7.1 Applications

StrikeNet would make the unmanned air assets of the battlefield available to all appropriately validated users (Figure 11). In addition to the lethal missions already discussed, StrikeNet could be tasked to provide and disseminate situation awareness data to any user regardless of location. This could include tank and other mechanized equipment drivers who could request and receive the same quality and quantity of real-time information in the cockpit as fighter, bomber, and helicopter pilots. Evacuees could send tactical status information to rescue forces so that air drops of supplies could be requested and locally coordinated. Like the Internet, once the basic concept is developed and enters use, unanticipated applications will follow.

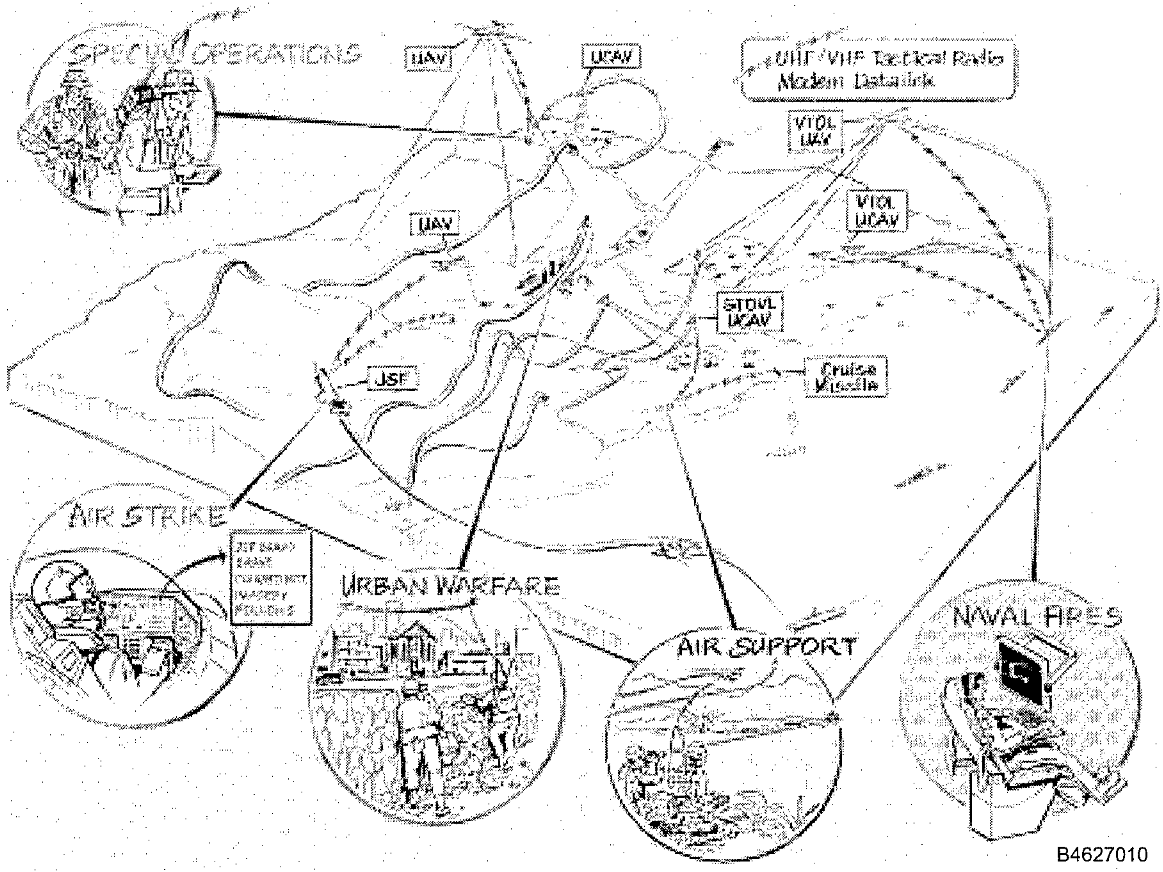


Figure 10. LM StrikeNet User-Controlled Air Vehicle System Concept

- **Close Air Support**
  - **Virtual Equivalent of Organic Long Range Artillery**
- **Real Time Intelligence in "Cockpit"**
  - **Surveillance / Control Platforms**
  - **Fighters**
  - **Bombers**
  - **Helicopters**
  - **Mechanized Equipment**
  - **Command Posts**
- **"Tight" ROE Situations**
  - **Urban Operations**
  - **Special Operations**
  - **Rescue Operations**
- **Other**
  - **Standoff / Support Jamming**
  - **Payload Delivery**
  - **Perimeter Defense**
  - **Etc.**

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Figure 11. LM StrikeNet System Applications

### 7.2 Benefits

A number of benefits are associated with the overall StrikeNet system concept (Figure 12). Included is the potential to reduce proliferation of individual UAV types to support individual users. Guaranteed access to a UAV network could be a more cost-effective option. Some high-priority users such as U.S. Special Operations Command (SOCOM) have even stated that they have no interest in owning or operating UAVs; they only want to use them[6].

### 7.3 Challenges

Although the StrikeNet concept is based on using available datalinks and/or modems and other system elements, there still will be a number of challenges associated with development and implementation. The challenges cover issues ranging from communications system compatibility through air vehicle design.

#### *7.3.1 Communications*

The battlefield is replete with service, system, and user-unique communications channels, frequencies, and formats. No existing tactical transceiver is compatible with the full range of UAV transmitters and receivers (Figure 13). Fortunately, potential solutions are under development to include the Joint Tactical Control System (TCS), the DOD Digital Modular Radio, and other multifunction digital tactical transceivers. TCS is perhaps the most directly applicable since it is intended to provide a universal control and information dissemination capability for all UAVs and control stations. It also is intended to be compatible

- **Universal Access to Unmanned Air Support Assets**
  - **Situation Awareness**
  - **Weapons on Target**
  - **Payloads on Target**
- **Direct Support of Maneuver Units (Sea / Land / Air)**
  - **Virtual Equivalent of Organic Air Assets**
  - **No "Visible" Intermediaries**
  - **SA Update Included at Minimal Additional Cost**
- **Efficient Dispatch of Incoming Requests**
  - **Quick Pairing of "Targets" and "Shooters"**
- **Efficient Dissemination of Tactical ISR Data**
  - **Direct Pipe From Sensor to Shooter**
- **Existing/Planned Assets In Robust Network Centric Tactical Architecture**
- **Alternative to Continued Unmanned Air Vehicle Type Proliferation**

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Figure 12. LM StrikeNet Benefits

with existing tactical data networks such as the Advanced Targeting Handoff System. While these systems are under development, however, there are existing systems and protocols such as the improved data modem (IDM) that exist in credit card-size, plug-in modules and that can support a limited initial operational capability. And even though the essence of the system described herein is line-of-sight controlled by local users, over-the-horizon connectivity with UAV and UCAV controllers and their command and control systems will still be required.

*7.3.2 Command and Control*

Another challenge for the StrikeNet system concept will be development of a command and control system that gives individual users easy access and provides timely and systematic responses. Low-priority users, for example, cannot be allowed to divert a UAV that is positioned to meet higher priority requirements. UAVs also cannot be allowed to wander aimlessly about the battlefield in response to multiple user requests. A prioritized user-request service system will need to be developed to manage the available assets and maximize overall system effectiveness. A candidate approach could be based on the COTS automated taxi dispatch system previously described. There are also a number of "sensor to shooter" concepts under development that could be adapted for the StrikeNet system concept.

*7.3.3 Security*

Universal ["Own Force"] accessibility, the essence of the StrikeNet system concept, also makes it a system security challenge. These challenges, however, are not unique. For example, the joint situation awareness datalink is intended to provide friendly forces with full awareness of friendly and enemy positions on the battlefield. Confining this information to validated

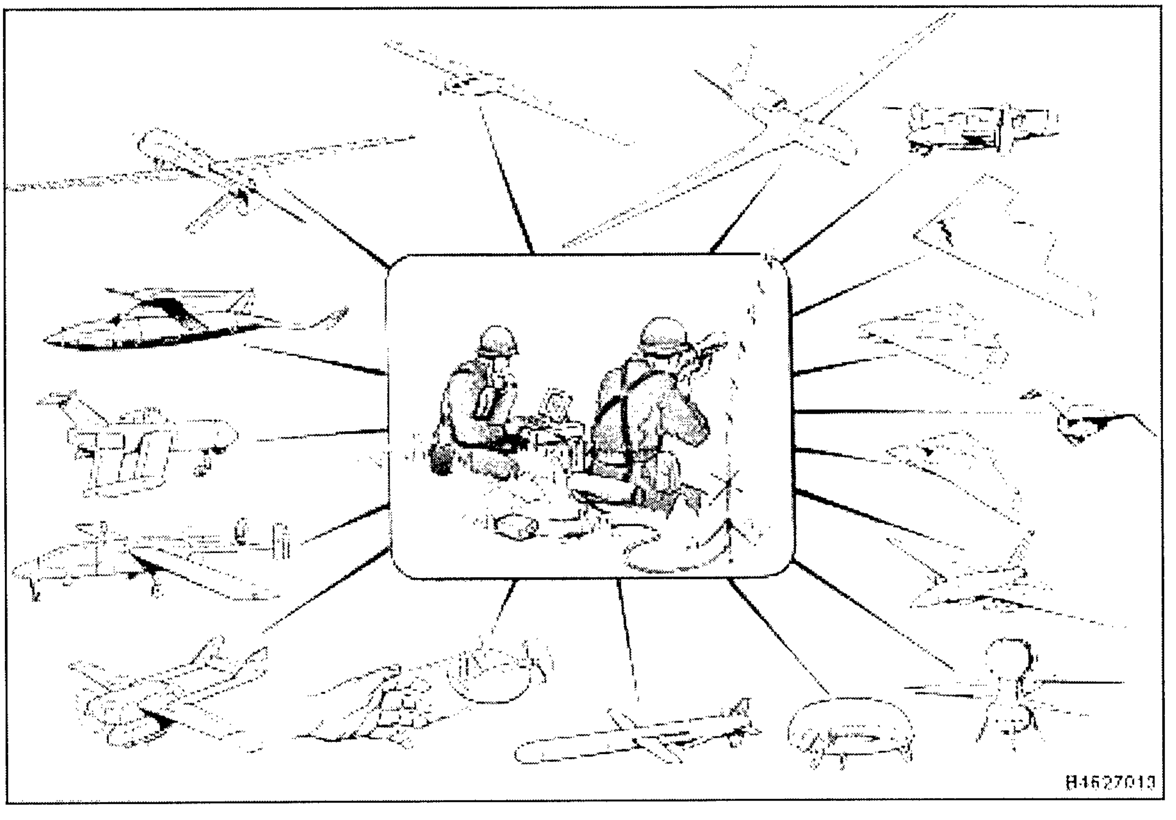

Figure 13. StrikeNet Communication Challenge

friendly users is no less challenging. In fact, the whole concept of network-centric warfare faces these challenges. Solutions include a number of well-developed approaches (e.g., secure authentication codes plus new and innovative technology). For example, StrikeNet will make extensive use of GPS for target and friendly force identification. User GPS locations, therefore, could be correlated with known or projected friendly locations and add an additional measure of security. In addition, COTS-developed facial and eye recognition could be employed to authenticate system users.

*7.3.4 Air Vehicle Compatibility*

The size and speed of development of the modern battlefield will be a StrikeNet challenge for the air vehicle (Figure 14). Air vehicles will probably operate in one of two modes while awaiting tasking, sitting strip alert, or flying CAP. The former mode will require a vehicle designed to operate from forward airfields and may require short and/or vertical takeoff and landing capabilities. The other mode will require air vehicles that can loiter efficiently and still respond quickly to time-critical needs at significant distances from their CAP position. Although contemporary UAVs are optimized for endurance, they have limited speed and maneuverability. Some, in fact, would have difficulty keeping up with mechanized ground units. A new class of air vehicle, therefore, will probably be required, one with fighter-like speed and tactical flexibility and bomber/transport-like cruise and loiter efficiency. The result could be an unmanned equivalent of the World War II medium-bomber concept. Finally, payload requirements and survivability will also drive air vehicle design. If UCAVs are required to carry current inventory vs. miniature weapons, for example, by definition they will not be small vehicles. If they are required to survive for long periods in hostile tactical environments, they will need compatible observables and/or survivability/defensive features. Integrating all these capabilities into a single air vehicle type will be no small challenge.

**7.4 Recommended Approach**

Lockheed Martin envisions a systematic approach to developing StrikeNet or equivalent system concepts. First, user communities should evaluate the concept and determine if it is consistent with their vision of the future scope and direction of tactical warfare. If so, CONOPS evaluation and experimentation should be undertaken by service battle labs. Industry could support the evaluations with modeling and simulation capabilities such as the LMTAS Man-in-the-Loop UCAV System Simulator. Combined operation exercise experiments using surrogate system elements could follow to verify simulation results. Finally, system-level concept studies could be initiated to develop candidate system-level solutions, technology needs and an orderly concept, and system development plans.

## 8. CONCLUDING REMARKS

The technology exists to enable evaluation, design, and development of a user-controlled air vehicle system that can provide individual combat users with access to and control of networks of UAVs. The key issues associated with the system concept are operational in nature and can be evaluated in simulation (constructive and man-in-the-loop) and in field experiments (using surrogates). Upon favorable evaluation of the concept, additional technologies could be developed to enhance the system concept. Included are automatic target recognition (ATR) to cue users to tactical developments, advanced data compression to improve response times, and multisource correlation to provide multiple users with tactical situation awareness previously available only to senior commanders.

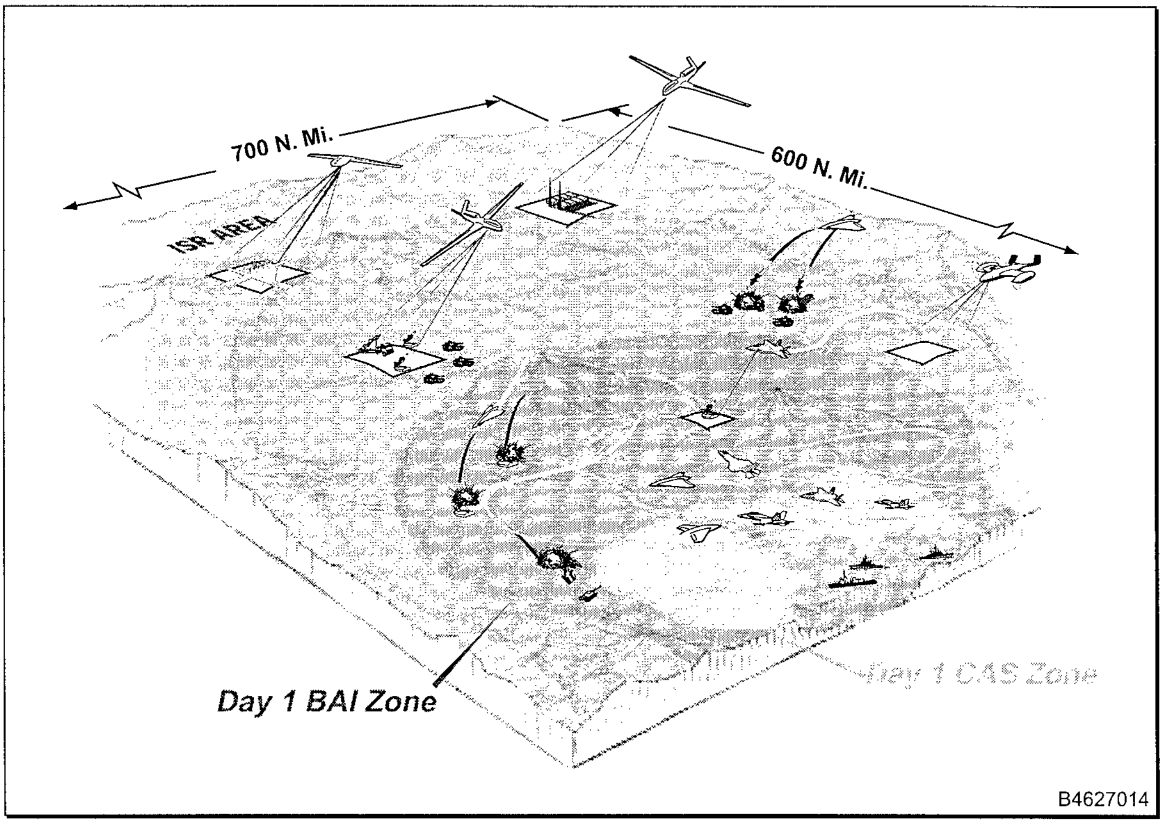


Figure 14. StrikeNet Operational Area Challenge

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